R. M. Harrison and S. J. De Mora: *Introductory Chemistry for the Environmental Sciences*, 2nd edition, Cambridge University Press, 1996, 373 pp., ISBN 0-521-48450-2 (paperback) £19.95/U.S.$29.95, ISBN 0-521-48172-4 (hardback) £55.00/U.S.$80.00.

Harrison and De Mora have revised the first edition of their book, *Introductory Chemistry for the Environmental Sciences*, which has an intended reading audience of college or university undergraduates who are studying or majoring in the environmental sciences, environmental chemistry, or ecology. Their intent is to present the basic concepts of chemistry within the context of the thermodynamic universe known at 'the environment'. The first three chapters are devoted to providing many of the underlying basics of general chemistry, inorganic chemistry, and physical chemistry. The treatment of organic chemistry is relegated to two subsections of their 3rd chapter. The authors present an overview of many fundamental concepts starting at the beginning with the nature of atoms and the primary features of atomic structure and atomic properties (Chapter 1). They then move on to discuss the nature of the chemical bond, fundamental chemical quantities, and some general properties of matter. After this general chemistry overview, the authors then proceed to cover some of the basic features of physical chemistry in Chapter 2 that are applicable to multiphasic environmental chemistry including chemical kinetics, photochemistry, thermodynamics, equilibria, electrochemistry, and colloid and surface chemistry. After presenting the essential background material, the authors then provide a somewhat systematic review of the chemistry of the elements by major groups and the relevance of each element from an environmental perspective (Chapter 3). Their relatively short book of 373 pp. has three remaining chapters that are devoted to analytical chemistry, environmental, biogeochemistry, and selected cases studies including a lengthy section on soil chemistry. This latter section should have been the subject of a complete chapter as opposed to a case study. In a traditional sense the broad review of soil chemistry is not a 'case study'.

I must commend the authors for taking the time and effort to put together a relatively coherent treatment of environmental chemistry that should provide a useful introduction to the subject for nonchemistry majors and a suitable review of basic subject matter with in an environmental context for more experienced chemists. However, in spite of their excellent efforts, there is still room for improvement. Some of my concerns are as follows:

I noticed that in several chapters there are no Table captions (e.g., Tables 1.1, 1.2, 1.3, etc.). In the early chapters the treatment can be in some cases quite sophisticated and in several other cases overly simplistic such as in the case of chemical reactions and stoichiometry. The authors should realize, that in order to be an academic major in science or engineering at most universities, that students will hve had some high school chemistry and most probably freshman chemistry in the form of either general chemistry or introductory physical chemistry.

In Chapter 2, on chemical kinetics, units are used often without any introduction or explanation. For example, the rate of the reaction of NO_2 and O_2 is expressed as a pseudo second-order reaction with reaction rate units of ppm hr^{-1}, when just prior to that presentation the units were given as M s^{-1}.

I would have liked to see the formal treatment of the subjects of thermodynamics and equilibria presented before the treatment of chemical kinetics, which is a normal order of consideration. We generally learn to deal first with the basic principles of chemical thermodynamics, then move on to the quantitative treatment of reactions at equilibrium, and finally address the kinetics of both reversible and irreversible reactions. The authors also might place more emphasis in their treatment of chemical thermodynamics on the lack of a formal relationship (with a few exceptions) between thermodynamics and kinetics. But the authors must be commended for using chemical examples that are relevant to environmental systems.

Sometimes the authors make statements that are not true within the current understanding of environmental chemistry. For example, they state on p. 67 that heterogeneous catalysis of SO_2 oxidation is 'of minor importance in the atmospheric oxidation of SO_2'. The implication within this context is that the primary pathway is oxidation by OH (hydroxyl radical) in the gas phase as stated on p. 291. The statements is somewhat misleading as it ignores the role of clouds and haze aerosol in this process. For example, it is predicted from large-scale atmospheric chemistry models that on a global basis more than 80% of SO_2 is converted heterogeneously in clouds.

In their treatment of ionic strength effects on solution equilibria, the authors need to mention that other formulations aside from the normal Debye–Huckel equation are used to determine activity coefficients over a range of ionic strengths encountered in aquatic systems (e.g., from $I = 0.001$ M in freshwaters, to 0.7 M in seawater, to 15 M in liquid sulfuric acid aerosols in the stratosphere).

The authors define pH correctly in terms of $\mathrm{pH} = -\log a_{\mathrm{H}^+}$, but then in their sample problems they simply use the concentration of the hydronium ion as obtained from a pH measurement with a glass electrode (e.g., pH $= 7.40$, thus $[H_3O^+] = 10^{-7.4}$ without any further explanation.

In Table 2.9, which gives the standard reduction potentials for a range of half-reactions, I note that many important environmental oxidants such as Mn(III)OOH, O_3, OH, and HOCl are missing. Furthermore, the authors write the corresponding half-reactions as irreversible reactions with a single arrow instead of reversible reactions with an equilibrium double arrow.

A major flaw in their general treatment of the subjects is the outdated nature of the principal references and recommended readings. For example, in Chapter 2 the latest reference included is 1988 and the most recommended reading is dated 1991. Thus, most of the examples and primary citations are 10 to 20 years out-of-date. Much has been discovered over the last 10 years.

The authors did a reasonable job reviewing the environmental significance of the individual elements of the periodic chart. However, they shortchange some elements such as Se and Br, which have a substantial body of chemistry of environmental importance. In other cases, such as the chemistry of Cr they note that Cr(VI) and Cr(III) are toxic but they fail to note that Cr(III) also is a micro-nutrient. In the case of Mn, they miss the potential role of Mn(III) completely.

The authors spent a great deal of space up front treating the kinetics of chemical reactions but then in most of their examples they simply present reaction stoichiometries without addressing either the kinetic aspects or the detailed chemical mechanisms. This may give the uninitiated reader the feeling that if one writes a stoichiometry, it is virtual the same as providing a reaction mechanism. In a future edition, the authors will need to emphasize the process of going from a reaction stoichiometry, to a kinetic equation, and finally to a reaction mechanism.

Chapter 4, which focuses on environmental analytical chemistry, is a very useful overview for a beginner in the environmenal field. However, the inclusion of thin-layer chromatography and paper chromatography seems to be unnecessary given the many more modern chromatographic techniques that are used today. This section should have been deleted in the 2nd edition.

In the new chapter on environmental biogeochemistry (Chapter 5), the authors give a broad outline of elemental cycles but they should have provided more detailed chemistry of the various pathways indicated in schematic form. In general, the student problems they present are very qualitative in nature and are not quantitatively challenging even though their treatment of thermodynamics, equilibria and kinetics is reasonably quantitative.

Their final chapter (Chapter 6) is called case studies, but in effect it is a limited treatment of subject matter that was too short for a full chapter but not really a serious treatment of case studie as most of us know them. For example, the reference list for Chapter 6 has as the most recent cited reference a paper by Gregory and Jackson that appeared in 1983. Much could have been done to make this chapter more modern, more current, and more relevant. I also note that much of the treatment of carbonate chemistry in Chapter 6 had been presented previously in Chapter 2.

In conclusion, I think this book provides a useful introduction to the subject for nonchemistry majors and a suitable review of basic environmental chemistry. The shortcomings might be addressed in a future edition.

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